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IS 15686 (2006): Recommendations for preparation of geological and geotechnical maps for river valley projects [WRD 5: Gelogical Investigation and Subsurface Exploration]

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IS 15686 : 2006
[Superseding IS 6065 (Part 1) : 1985]

भारतीय मानक

नदी घाटी परियोजनाओं के लिए भूवैज्ञानिक और भूतकनीकी मानचित्रों को तैयार करने की अनुशंसाएँ

Indian Standard

RECOMMENDATIONS FOR PREPARATION OF GEOLOGICAL AND GEOTECHNICAL MAPS FOR RIVER VALLEY PROJECTS

ICS 93.020

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BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Geological Investigations and Subsurface Exploration Sectional Committee had been approved by the Water Resources Division Council.

This standard incorporates the recommendations given in IS 6065 (Part 1) : 1985 'Recommendations for the preparation of geological and geotechnical maps for river valley project: Part 1 Scales (*first revision*)' along with details for format and method of presentation of geological and geotechnical maps which was initially proposed for publication as IS 6065 (Part 2). However, for the purpose of ease of use and availability of consolidated information, the standard is being published as a comprehensive document. This standard replaces IS 6065 (Part 1) : 1985 which is being withdrawn.

The purpose of these guidelines is to achieve uniformity in the preparation and presentation of geological maps and to assist the field geologist in preparing geological drawings that may be readily understood by the user. Accuracy, clarity and proper emphasis in the presentation of the data are important requirements.

A geological map should stand by itself. The user should not have to read the text of the report in order to interpret the map. The maps should be clear, symbols should be uniform, different types and weights of lines should be chosen to illustrate different geological data. To achieve this, major geological data should be most prominently displayed. Map explanations should be complete and comprehensive.

It is very important to differentiate between interpretative and factual data and there should be some indication of relative reliability of the data. The purpose and scale of the map should be duly considered. A regional map may show only generalized formation, contacts and structures. A dam site map focuses attention on greater details in a small area. Ingenuity and sound judgment are essential for presentation of the diverse details required in engineering geology studies.

In river valley projects, the geological surveys are usually undertaken in different stages and the engineering geological maps are prepared accordingly in order to meet the requirements of planning, design and construction on different scales varying from regional one in reconnaissance stage to large scale in construction stage.

A re-classification of the stages has been suggested with the purpose that all the investigation should be completed prior to preparation of Detailed Project Report (DPR).

The composition of the Committee responsible for the formulation of this standard is given at Annex A.

It has been assumed in the formulation of this standard that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance, it has been prepared.

Indian Standard

RECOMMENDATIONS FOR PREPARATION OF GEOLOGICAL AND GEOTECHNICAL MAPS FOR RIVER VALLEY PROJECTS

1 SCOPE

This standard gives the guidelines for preparation of format and method of presentation of geological and geotechnical maps and their scales for river valley projects required for various stages of investigation, namely, reconnaissance or pre-feasibility, preliminary investigation or feasibility, detailed investigation or detailed project report (DPR) and construction.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
7422 (Part 5) : 1992	Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs: Part 5 Line symbols for formation contacts and structural features
10711 : 2001	Technical product documentation — Sizes and layout of drawing sheets (*first revision*)
15662 : 2006	Geological exploration for gravity dams and overflow structures — Code of practice

3 BASE MAPS

A variety of base maps on which geological information is incorporated, such as, toposheets, country and forest service maps, project topography, aerial photographs, minerals maps or maps, which are a composite of data from different sources or simply a traverse line, are available and can be used.

If a topographical map is used for the purpose, it is desirable to subdue the intensity of the contours. The use of such screened maps allows the superimposed data to stand out prominently and clearly on the topographic background.

Air photos and satellite imageries may also serve as base maps. Geological data may be plotted on the photographs in the field and subsequently transferred on a translucent overlay or as a line drawing. Geological maps, which are line drawings based on aerial photographs, should have a note defining the nature of the base to warn the user of horizontal distortion and variation of scale depending on the distance from the centre of the photograph. In addition, it should be clearly stated whether the air photo base is a controlled or uncontrolled mosaic, ordinary vertical photo, rectified photo or ortho-photograph. The geological data thus collected should be transferred on topographic maps with a note.

4 DIFFERENT STAGES OF PROJECT AND RELEVANT SCALES OF MAP

Geological explorations for engineering projects are subdivided into four stages as given in IS 15662. The different stages of project and relevant scales of map are elaborated in **4.1** to **4.4**.

4.1 Reconnaissance or Pre-feasibility Stage

During the reconnaissance or pre-feasibility stage, the objective is to bring out the overall geological features of the area for guiding the proper planning of the project. Therefore, the scale of mapping need not be very large and the appropriate scales are 1:50 000 or 1:25 000 on contour interval of generally 40 m/20 m respectively. Aerial photographic studies should also be done on 1:50 000 or 1:25 000 scale depending upon terrain conditions and availability of photographs.

4.2 Preliminary Investigation or Feasibility Stage

During preliminary investigation or feasibility stage, the objective is to collect further detailed information about the surface and subsurface geological condition, as such, detailed surface geological mapping is done on larger scales with preliminary subsurface explorations. The scale of mapping varies with structures. The geological mapping of reservoir, construction material sites and updated geological plans of tunnels/channels is done on 1:15 000 or 1:10 000 scale on 1 to 5 m contour interval. Concrete dam/earth and rockfill dam, their appurtenant structures and powerhouse site are mapped on 1:5 000 or nearest available scale topo maps having 2 to 5 m contour interval.

In concrete dam, an area equal to twice the height of the dam towards the upstream and downstream direction should be covered. The mapping should be extended up to 100 m above the top of the dam in areas of immature topography and 25 m in mature topography. In earth and rockfill dam mapping should be extended in an area about four times the height of the dam in upstream and downstream direction from the dam axis. Height wise coverage of the area should be same as that of concrete dam. At dam sites involving problems of the instability of hill slopes, the mapping should be extended to cover such areas also. The areas of special importance in the reservoir like landslides, mineral deposits, etc, should be mapped on the scale of 1:5 000 and 1:2 000 having 5 and 2.5 m contour intervals respectively. The logging of exploratory drill holes, drifts, pits and trenches should be done on 1:100 scale.

4.3 Detailed Investigation or Detailed Project Report Stage

During detailed investigation or DPR stage, the objective is to provide detailed geological information of the appurtenant structure sites for their final design, and as such, the geological mapping should be done on a larger scale. Areas like access roads, adit and quarry sites should be covered on 1:2 000 scale with 1 to 5 m contour interval. Detailed geological mapping around the dam, powerhouse and ancillary structures is recommended on 1:1 000 scale with 1 to 2 m contour interval for their geotechnical assessment. All the tunnel portals should be mapped on 1:500 scale with 1 to 2 m contour interval and the geological logs of drill holes, drifts, pits and trenches should also be updated. The maps prepared during this stage could be termed as geotechnical maps. Besides showing the boundaries of geologically different units of overburden and rock, the legend to the different units should show the expected variation in properties, such as grain size, penetration resistance, cohesion and angle of friction values, plasticity, permeability, etc, as gathered from tested samples. The map should also show the results of geophysical studies, like, longitudinal wave velocity, Poisson's ratio, Young's modulus and electrical resistivity in different formational units.

4.4 Construction Stage

During construction stage, the objective is to keep a record of geological features exposed during the construction of the project and to apprise the construction and design engineers regarding any special geological features revealed in the excavation which could not be inferred in the pre-construction stage explorations so that the new geological features are taken care of in the final design and construction. The final foundation grade geological mapping should be done on 1:100 scale with 1 m contour interval for concrete dams, powerhouse sites, on 1 : 500 scale with 1 to 2 m contour interval for earth and rockfill dams, tunnel portals and on 1:1 000 m scale with 1 to 2.5 m contour interval for hydel channels, updated geological plans of dam, powerhouse and ancillary structures. For underground powerhouse excavation, the scale of mapping is recommended to be 1:100. Similarly, for 3 Dimensional logging of tunnels 1:100 scale should be adopted. Surface geological mapping of critical areas in tunnel alignment (for example, depression shown or drainage crossing) should be done locally on 1:1 000 scale.

Table 1 shows the recommended scales for geological and geotechnical mapping for river valley projects.

5 TYPES OF MAPS

5.1 The degree of detail shown on any geological map depends largely on the objective or intended use and scale of the map. A regional map, using a small scale, may show simply the generalized position of major geological formation and structures. In contrast, a dam site map, using a large scale, should focus on the detailed conditions of a small area.

5.2 The geological map of a proposed reservoir generally combines regional information with details in selected areas. At reservoir boundaries, attention should be given to presenting the relations between formations and geological structures cutting across reservoir boundaries. This is essential to understand the problems of:

a) landslide and reservoir rim stability;
b) bank storage and holding capabilities including path of possible and likely points of exit;
c) realignment of existing man-made structures, such as, highways; and
d) submergence of mines and mineral deposits. This requires considerable geological details to be incorporated in localized areas of the reservoir map, even though separate studies with supporting large scale mapping have been carried out.

Ingenuity and judgement are essential to effectively present diverse data without obscuring the topography or position of existing or proposed engineering structures. Such data should be major formation boundaries and regional joint system trends together with localized joint and pertinent facies changes or ground water contours and the position of springs and wells.

5.3 There are several types of general and special purpose maps. Some of the commonly used are listed in **5.3.1** to **5.3.9**.

5.3.1 *Outcrop*

Position boundaries of natural formation outcrops (and exposures in man-made openings) are shown.

Table 1 Recommended Scales for Geological and Geotechnical Mapping for River Valley Projects

(*Clause* 4.4)

Sl No. (1)	Project Stage (2)	Description of Geological/ Geotechnical Map (3)	Recommended Scales (4)	Contour Interval (5)
i)	Reconnaissance or Pre-feasibility Stage	Satellite imageries/aerial photographic studies: a) For selection of dam sites b) For choice of tunnel/channel-alignments c) For regional geological and lineament interpretation d) For reservoir area geology, mineral occurrences of significance and structural features	1:50 000 or 1:25 000	40 or 20
		Regional geological studies for dam sites, tunnel/channel alignment, powerhouse sites, construction material sites and mineral occurrences of significance	1:50 000 or 1:25 000	40 or 20
ii)	Preliminary Investigations or Feasibility Stage	Aerial photographic studies useful adjunct to surface mapping to collect further information about surface conditions around the probable sites selected and to locate the types and characteristics of construction materials	1:25 000 or 1:10 000	5
		Geological mapping of reservoir, construction material sites and updated geological plan of tunnels/channels	1:15 000 to 1:10 000	1 to 5
		Geological mapping of dam site and appurtenant structures, powerhouse site	1:5 000	2 to 5
		Logging of exploratory drifts, pits, trenches and drill holes	1:100	—
iii)	Detailed Investigation or Detailed Project Report Stage	Geological mapping of reservoir area, construction material sites, access roads	1:2 000	1 to 5
		Geological mapping of tunnel/channel alignment, powerhouse site, dam and appurtenant structures	1:1 000	1 to 2
		Geological mapping of areas of special importance in the reservoir like landslides and major structural features	1:2 000 to 1:1 000	1 to 2
		Geological mapping of borrow areas and quarry sites	1:2 000 to 1:1 000	1 to 2
		Updated geological plans of dam and ancillary structures, powerhouse areas, critical areas in open channel area	1:1 000	1 to 2
		Geological mapping of all tunnel portals	1:500	1 to 2
		Logging / Updating of exploratory drifts, pilot tunnels, pits, trenches and drill holes	1:100	1
iv)	Construction Stage	Foundation grade geotechnical mapping of earth and rockfill dam	1:500 to 1:100	1 to 2
		Foundation grade geotechnical mapping of concrete dam blocks, surface and underground powerhouse excavations, tunnels	1:100	1

In this as well as in other types of maps a brief statement in explanation or notes on the method (for example , surveyed or eyeballed on topographic map) by which outcrop boundaries, formation contacts and other features were located, may be included.

5.3.2 *Surface Geology*

Formation outcrops, rock types and distribution of distinction between types of surfacial materials, such as, glacial moraine or outwash, stream deposits, talus slopes and terraces are shown. Relative geological ages of various units as well as structural and geomorphic features may also be recognized.

5.3.3 *Formation Geology*

Distribution of formations and structures with contact lines. The contact lines should be solid, dashed or dotted as appropriate.

5.3.4 *Rock Surface Contours*

Contours drawn on Top of Rock (Bedrock) or on top of sound unweathered rock (fresh rock). The contours for fresh rock usually reflect the base or depth of weathering.

5.3.5 *Structure (Sub-surface) Contours*

A contour map with contours drawn to depict a surface, such as, the top of a formation, a selected identifiable horizon (or key bed) of a formation, or an unconformable contact.

5.3.6 *Isopach*

Lines connecting points of equal thickness, that is, contours showing variation in thickness of some selected zone of material, such as, overburden or a formation.

5.3.7 *Hydrogeology*

Used to show the shape or piezometric surface of the groundwater body at a specified time. Isopachs (*see* **5.3.6**) are sometimes used to show thickness (shape) of aquifers.

Hydrogeological maps and sections may show type of aquifers, varying degrees of transmissibility, quality of groundwater, rise and fall of water levels and the amount of groundwater withdrawal or recharge and effect of such action.

If several groundwater bodies exist, the hydrogeological map should identify or distinguish them as, perched, unconfined or confined. The water table and piezometric surface should be clearly defined.

5.3.8 *Special Purpose*

Maps not covered in **5.3.1** to **5.3.7**, such as, block diagrams or which show only joints and faults, or sand and gravel deposits or pertinent geological data adjacent to a proposed canal line (strip map) or along the route of a power transmission line. In some cases only the types of geological materials actually on the line are shown by brackets with suitably described symbols.

5.3.9 *Composite*

A composite of several of the types mentioned in **5.3.1** to **5.3.8**.

5.3.10 *Mineral Maps*

Maps showing extent and quantum of occurrences of minerals of significance.

6 GRAPHIC SYMBOLS

6.1 Standard Symbols

Standard symbols for types of geological data shown in engineering geological maps, as given in IS 7422 (Part 5), should be used.

6.2 Colour Coding

In general, choice of line and geometric symbols made to present data on geological map should be that which will enable black and white prints to be read and used without difficulty (*see* **6.1**). Colour coding is generally used to emphasize different formations and facilitate rapid comprehension of information presented on the map. Colour should be selected to give good contrast and to follow as far as possible the common usage, such as, yellow for alluvium and red for igneous rocks.

6.3 Explanation and Notes

6.3.1 An explanation should appear on each sheet of a geological map. It should include a stratigraphic or columnar section presenting the sequence, structural relationship and description of the geologic units included on the map. It should also include representations of all of the colour, line and letter of geometric symbols used on the map along with concise, clear descriptions of the specific geological data which each of them represent. This should be done even though many of the symbols are standard , in order that each map may be used without reference to lists of standard symbols. In addition, notes are usually needed to provide data on the base map, source of geologic data and reference drawings.

6.3.2 The name and the concise engineering geological description of formation should be given to indicate the lithology and important characteristics, such as, swelling clay, friable sandstone; fissile shale; previous tuff; break down to sand with few freeze-thaw cycles and clay shale-air slakes rapidly.

6.4 Stratigraphic and Columnar Sections

6.4.1 The value and use of a geological map gets increased by including a stratigraphic section which shows at a glance the normal sequence to strata as well as the relative geologic ages-youngest at the top and oldest at the bottom. Listing of geological units in the order of age with colour coded boxes that also show the letter-code is common practice.

6.4.2 The simple stratigraphic section can be amplified to form a columnar section, which presents the main elements of geologic history at a glance. Thus, the columnar section may show information, such as, comparative thickness of formations; conformable, unconformable or faulted contacts; simplified relations between sedimentary strata and intrusive-extrusive igneous formation; differential weathering characteristics and resulting topographic expression; faulting and other features important either to comprehending the geologic history or to the formulation of engineering conclusions.

6.4.3 Both the simple stratigraphic section and columnar section should be colour-coded in conformance with the map to facilitate comprehension.

6.5 Special Symbols

Special symbols, should be used wherever they will clarify, emphasize or summarize important elements of the geologic conditions, which would otherwise need to be extracted from the map and text and compiled. The major and minor joint sets should be identified with suitable distinction between regional and local sets.

A stenographic plot of joint attitudes is useful in showing the degree of dispersion and abundance of joint sets.

7 GENERAL REQUIREMENTS

7.1 Accuracy, clarity and proper emphasis are the important requirements in the data presentation. These can be better achieved as given in **7.1.1** to **7.1.3**.

7.1.1 It should be easy to distinguish between different types of information, such as, lines representing joints and faults, areas of formation outcrops, artificial exposure and surfacial materials. Packing a map with volume and variety of data so that it becomes laborious to decipher, should be avoided. Packing should be avoided by using two or more maps (with same base map and scale) and placing selected groups of data on each or by using several translucent overlays.

7.1.2 Suitable choice of colour strength, line weight and type of symbol enables the user to read the map quickly and identify major elements of geological structure or joint system trends or distribution of formations. The user may look closer and identify details such as dip-strike data on joints, faults or schistosity without labouring to differentiate between the several types of data shown.

7.1.3 Placing of non-essential data on the map, thereby obscuring important information should be avoided. Such data should be excluded or be given elsewhere with suitable reference.

7.1.4 In complex geological maps, small but important areas may be so crowded with detail that they are difficult to decipher. Such areas should be redrawn at a larger scale as an inset on the same map or as a completely separate map.

7.2 Map Scales

Line or bar scales should be used since many geological maps in the course of their use, may be enlarged or reduced.

7.3 Orientation

An arrow indicating north should invariably be given. The coordinate system, triangulation stations, section corners or other surveyed points should be shown to permit accurate location of points on the map.

7.4 Lines of Geologic Sections

Lines showing the length and location of accompanying geological sections should be shown and referenced by drawing number.

7.5 Location of Geophysical Surveys

The data from geophysical surveys should be indicated on the map, as far as possible.

7.6 Standard Drawing Sizes

Standard size of drawings as per IS 10711 should be used.

7.7 Author

The identity of the geologist(s) (name not initials) who made the map and sections or participated in the field work should be given on the map. This includes preliminary maps as well as final maps. In addition the identity of the personnel, who reviewed or approved these maps, should appear on the map.

8 MAP USAGE FOR SPECIFICATIONS

8.1 The field work which results in a geological map starts by visual study of outcrops and is supplemented by consideration of vegetation, soil composition and colour and subsurface data from pits and drill holes. Careful choice in plotting the factual and interpretative data will enable the user to see the facts and to independently judge the soundness of the interpretation and the probable accuracy and reliability of the mapping.

8.2 Many geological maps produced during the later stages of investigation, particularly in the final design and investigation stage, are used in preparing the drawings showing geological data which are included in specifications for bidding and construction purposes. Current policy governing the preparation of such geologic specification drawings requires that all competent geologic facts be shown, without interpretations.

8.3 The conversion of geologic map for use in specifications may be done by individuals not personally familiar with the field geology. It is, therefore, vital that the field geologist during field work and map compilation should distinguish clearly between fact and interpretation and ensure that the distinction is clearly revealed by the symbols and drafting employed in preparing the final drawings. Supervising field geologists should conduct their review, not only for technical soundness of the geological data, but also for presentation of facts *versus* interpretation.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Geological Investigations and Subsurface Exploration Sectional Committee, WRD 05

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Geological Survey of India, Dehradun	DR P. C. NAWANI (***Chairman***)
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Narmada & Water Resources Department, Government of Gujarat, Gandhinagar	SUPERINTENDING ENGINEER (DAMS) SUPERINTENDING ENGINEER (GEOLOGY) (*Alternate*)
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Member Secretary
MS BHAVANA SHARMA
Assistant Director (WRD), BIS

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